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On the Treatment of Fractured Shafts of Bone
in Children; Simple, Complicated
and Compound.



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ON THE TREATMENT OF FRACTURED SHAFTS OF BONE IN CHILDREN; SIMPLE, COMPLICATED AND COMPOUND.

BY THOMAS H. MANLEY, M.D.

Fracture is, perhaps, the most common type of severe trauma incident to childhood, especially in the male sex.

When the shafts of bones are involved, although union is more rapid than in the adult and repair is more complete, there are several special features of treatment of them, to be observed in the youth, if we would avoid possible dangers to the integrity of the damaged limb and secure the fullest degree of strength and function in it after recovery.

Anatomic Considerations.—It should be always remembered, that the bones of a child are immature structures, neither the epiphyses nor the apophyses have yet fused with the shaft by osseous union; through the absence of full calcification, the bone possesses unusual resiliency and elasticity. Vascular and cartilaginous elements predominate in the osseous structures in infancy; both progressively diminishing as age advances. The cancellous heads are the centers of great vascularity; the periosteum thick and is everywhere ramified by vessels which course through it and penetrate the cortex through Howship's lacunæ. The medullary elements share in the activity of the nutritive forces, as is demonstrated by the bright crimson color of the bone marrow and its great proneness to bleed freely, when lacerated. Nutrition and growth of the bone shafts at this epoch of life are

maintained, by *periosteal* and *endosteal* sources; *i. e.*, from the circumference and ends. Layer after layer of the myeloplaxes bud from the true bone roots, the cancellous heads, and are deposited in consecutive layers, on either end, preliminary to fusion and the formation of Haversian systems; while simultaneously from the circumference, the osteo-blastic layer of periosteum is steadily superadding concentric lamellæ, of neoblastic bone corpuscles.

The overlying soft parts are in a high state of nutritive activity; neither the effect of time, nor occupation, nor the degenerative consequences of various local or constitutional disease have made their impress on the structures of the limbs; arterial sclerosis, venous varix, or territorial obliteration of the capillaries have not yet appeared.

Although, in the young, growing limb the sanguinous supply is abundant, it is important to note that the volume of force of the blood-current in the great blood-trunks is not as great as in the adult, and accordingly in a corresponding degree, it is unable to resist the effects of pressure or tension.

Etiology of Fracture in Childhood and Youth.—Traumatic disorganization of bone in children more often results from direct, than indirect force; from the latter, we will more often find, epiphyseal separation or dislocation resulting; Colles' or Pott's fracture in them, is rarely, if ever, witnessed.

It has seemed that the shock attending the average simple fracture of a limb, was less in children than in adults. Muscular action as a conservative factor, plays an unimportant *role* in these fractures. As a rule force must be directly applied; or at all events in close proximity to where the bone sunders. This will explain why we so rarely see the shafts or apophyses shattered, after sudden torsion or twists contiguous to a joint.

I am not familiar with any constitutional disease in a child which predisposes to fracture. There is no doubt, but in the cachectic, rickety, syphilitic, or badly fed the bones are more vulnerable and prone to

give way to violence; but then, the effects of malnutrition are widespread, involving equally the soft parts and organs, as well as the osseous structures.

It can not be said, therefore, that as a rule, there are any predisposing causes of fracture during the stage of growth and development; in this respect these fractures being widely at variance with the etiology of the same lesion, in the adult. That there is a strongly marked predisposition to fracture in some adult individuals no one can deny who has treated a large number of fractured shafts; but in my own experience with this traumatism in the child, I have never been able to find evidence to support the probability of predisposition.

It seems, however, that with those who have had a large experience in the treatment of broken bones in modern children's hospitals, a belief prevails, that there are dyscrasia tending to fracture in the young. Thus, Power speaks of osteopsathyrosis, or fragilitas ossium, rickets and even an inherited tendency, leading to fracture in young children. (Surgical Diseases of Children, D. Power, p. 160.) It is well to remember in this connection, that most hospitals for children are filled with unhappy waifs, illegitimate offspring and poor poverty-stricken orphans, with feeble constitutions, forming a class quite distinct from those more fortunately situated in the outside world, and not to be readily contrasted, in their morbid tendencies, with average fairly fed children, at home.

Morbid Anatomy.—In the child the nature and extent of tissue disorganization in fracture are not identical with the adult. As the degree of force necessary to break or crack the bone shaft is less, we will not so frequently find simultaneous laceration of contiguous parts, as the vascular or neural; the osseous elements being more elastic and containing more organic material there is rarely shattering unless, great crushing force acts over a limited area; the bone being less brittle, the double bladed spurs seen in the oblique fracture of an adult, are not encoun-

tered, as the rent through the shaft is generally in a transverse direction. The periosteum being thick, and the muscular power comparatively feeble, marked displacement, over-riding of the fragments or surface deformity are not such prominent characteristics as in the matured man.

Joint implication constitutes one of their most serious features. Fracture through any part invested by the perichondrium on opening through the synovial membrane, or involving the "growing line," the epiphyseal bridge, in spite of what particular line of treatment is followed, may result in marked limitation of joint action, articular deformity, or permanent arrest of growth of the limb. It is probable that in all severe fractures, growth in the limb is in the abeyance, until after repair is complete.

In many cases of femoral fracture, shortening has been noticed by me, when perfect apposition of the fragments was effected, with ultimate solid union, without any deflection or bulging at the point of fracture; thus temporary arrest of growth was the only possible explanation for it. The shortening in some cases was slight, yet clearly apparent on measurement. Similar shortening occurs, after arthritic or osseous disease in children, and reasoning from analogy, we may expect to find it after fracture when there is long confinement in bed.

Fractures, or diastasis, contiguous to the arthritic structure give rise to difficulty in diagnosis and treatment, because of the copious, sanguinous extravasate into the peri-arthritic structures or the capsule and prompt diffusive inflammation, which so generally follows. At the complicated articulation of the elbow, the T. fracture through the head of the humerus is almost certain to leave some impairment in motion. In the process of repair, there is sometimes a hypertosis, with a pushing forward and outward of the trochlear hollow of the olecranon; resulting in a disturbance of the mechanical relations between the articular surfaces.

Diastasis through the epiphysis, when the extent of displacement is slight, in my experience, unites more quickly than osseous fracture. But, when this occurs under fleshy parts like the shoulder or hip in the delicate or strumous, its recognition is not only difficult, but it may lead to arrest of growth or impairment of joint action. Such results, however, are exceedingly uncommon. None have ever come under my observation.

In connection with this subject of diastases or fracture through joints, in order that judicious treatment may be instituted, an accurate knowledge of the condition existing is necessary; and here is where the difficulty comes, for oftentimes this is practically impossible, as every unbiased, experienced surgeon must admit.

In epiphyseal separation of the humeral head at the shoulder joint, although some writers of fertile imagination and remarkable descriptive power of what does not exist, have laid down *seriatim* the differential features between this and bone luxation. Jonathan Hutchinson states that all, or nearly all so-called shoulder-joint dislocations are but epiphyseal diastases. This is no doubt an exaggeration, though not far from the truth.

In either epiphyseal loosening at the shoulder-joint intra-articular fracture or dislocation in the child, although the anatomic elements involved are dissimilar, the reactionary efforts are quite the same in all; hemorrhage, laceration of adjacent soft parts, inflammation, exudation with consecutive fibrosis and extensive adhesions in all or many of the overlying parts, occurs in each equally frequent.

Compound Fracture in Children.—In the present state of our knowledge and the great advances made in the surgery of the extremities, the time has come, when compound, comminuted or complicated fractures in children, should be separately considered and their distinctive etiology, pathology and treatment should be taught in our medical schools. Nevertheless, the

antiquated and vicious system of dealing with all types of fracture, in the various epochs of life, on the same principle, is yet adhered to, even in our latest textbooks on surgery. It has been noted, that the limbs, during the evolution of growth, are organically, totally, unlike those of middle or advanced age, being less firmly set, highly vascular and elastic. The lower extremities of the child carrying a lighter body are comparatively exempt from those shocks and jars inseparable from advancing years.

The recuperative energy of the osseous system of the child possesses marvelous activity, for it can not only repair, but also reproduce or restore shattered or destroyed segments of a bone-shaft. Therefore, by the aid of antiseptics and by utilizing those osteoplastic procedures so elaborated and graphically described by M. Ollier, we are often enabled to preserve limbs, sometimes so mutilated, as to seem to justify immediate amputation.

Morbid Anatomy and Pathology of Juvenile Compound Fracture.—Compound fracture is less frequent in the young, than in the adult for several reasons. The first is, at this stage of life the occupations of children are not so dangerous. Serious injuries most often befall them, however, through their venturesome tendencies and heedlessness. Proportionally for their volume, the solid elements of their bone shafts are better protected by the enveloping parts, which are highly elastic; as their fractures are mostly transverse, muscular action is weaker and the periosteal investment thicker, displacement after fracture is slight. The younger the living tissues the greater the resistance to the influence of pathogenic germs which may infect the protoplasmic elements, everything else being equal.

Compound fractures only become grave injuries in a child, when the violence has been so great as to totally destroy the limb, or when large vessels have been opened and a considerable quantity of blood has been lost; as even moderate exsanguination in childhood is often attended with alarming shock.

The loss of a considerable area of integument by primary violence or secondary gangrène is a serious complication. The skin can never be reproduced, but frequently the bone can. The shock succeeding compound fracture in children is usually greater than in the adult, and the depression of the vaso-motor system is so pronounced that a marked pallor and depression of temperature pervade the entire surface of the body. Compound fractures which open into the joints, when sepsis is prevented and the vascular current is intact beyond, often do suprisingly well.

Several such injuries involving the elbow and ankle joints of children have been under my care. When there had been no loss of bone, whether the fissuring of bone extends into epiphyseal line or not, it is remarkable what a large degree of function is restored. What frequently imparts a serious aspect in these cases is when the patient is strumous, and when inflammatory changes degenerate into widespread, suppurative infiltration, with sloughing.

In all these cases of compound arthritic fracture, as in the simple variety involving joints, more or less inevitable displacement of the fragments, hyperostosis in callous formation and organized or semi-organized tendino-muscular adhesions, for some time after osseous consolidation, more or less lock the joint and induce muscular atrophy. In the youth, all of those pathologic conditions, as a rule so serious and often permanent, in the fully developed individual, are largely minimized in the ultimate effects by appropriate treatment and the innate tendency of the economy to restore adjustment and a large degree of function in an injured part.

Treatment—This brief review of the subject will not permit anything like an extended notice of the subject of diagnosis, something which must always precedes definite specialised treatment, but to omit it altogether would be to vitiate, largely, whatever value the present contribution may possess. It may be said, as a general rule. that fractures in children are

most difficult of detection. In fact, in fractures contiguous with joints, it is sometimes quite impossible to recognize them. In this class, the safest course to pursue is to proceed on the assumption that there is a fracture, and apply treatment. It has been pointed out, that immediately after many fractures, tumefaction, sanguinous extravasate and muscular spasm, render examination severely painful, difficult, and sometimes indefinite. More than once, when a case of injury, assumed to be fracture, has come under my care, when by moderate manipulation its detection could not be determined, I have made a show of adjustment and set the limb aside, under soothing dressings until the following day, when the real examination was made. Almost invariably now, crepitus could be detected and the quality of the osseous disorganization ascertained with the infliction of no severe pain.

Incision as an aid in diagnosis of fracture of a bone shaft is a procedure of questionable expediency. Notwithstanding what asepsis may prevent in flesh wounds, when we deliberately open into a fracture of a bone shaft, we introduce fresh complications. We at once make a simple, a compound fracture and expose the parts to the dangers of suppurative infiltration or necrosis. In any other than rare and exceptional cases as a diagnostic resource, the incision should be condemned. A practical knowledge of the general rules of diagnosis will seldom fail us without resorting to this extreme measure. It is only necessary that the examination be made with gentleness and thoroughness; and when the suspected fracture be located contiguously with the shoulder or hip-joint, the patient should be placed in a position of complete muscular relaxation on a table or in bed, on the back. In this connection it may be well to give a warning against the possibility of diagnosing fractures which do not exist.

It certainly is no reflection on one's knowledge or skill when in doubt about the existence of fracture to

frankly confess it to the patient, his friends or relatives; but it becomes a reprehensive line of conduct to decide alone, on a case and put up the limb in an apparatus or adjustment, for the cure of an imaginary condition. Such mistaken cases have come under my observation in nearly all the long bone shafts, at the wrist and the elbow, the clavicle, scapula and neck of the humerus, the femur, the tibia and fibula.

Pulmonary anesthesia is an invaluable adjuvant in diagnosis of various fractures. It may be laid down however, as a law, *that when detection is only possible by this agent in the case of bone trauma, the extent of damage is not great, and the establishment of definite diagnosis will not materially effect treatment.* It is very seldom necessary in the youth, and is not without its dangers. We usually resort to it, in order to avoid the imputation of ignorance or neglect in complex cases, perhaps also as an aid in reduction or setting.

Treatment—Simple Fracture.—The limb of an infant or youth is more intolerant of protracted restraint or severe pressure than the adult; with him are commonly incomplete fractures, or non-displacement of the fragments, and hence not a few of them, are overlooked, or not discovered, until a large callus or deflexion attracts attention. Although primary union of bone is prompt, the uniting bone slowly calcifies, and the tendency to bowing remains for some time after apparent union, at the sight of fracture.

A mistaken impression prevails, that treatment of fracture should be instituted on the spot, *sur le champ*, as though the limb must perish or fall apart, unless it be at once placed in a rigid adjustment. This view has often led to most disastrous consequences and calls loudly for the voice of a Pott, or of a world-famed luminary, like Senn, to condemn it.

The aim to be sought for *immediately* after simple fracture, is to place the limb in a comfortable position. In none is this more important than in the tender susceptible child. Sometimes, this end is effectively

accomplished by immediately setting the bones and splinting the limb, while in others the best splint is a bed, the limb well bolstered and enveloped in soothing dressings, until the following day or such time as the inflammatory disturbance has disappeared, tumefaction has diminished and muscular spasm has passed off. Nothing has been lost by this delay, as the work of repair is impossible until the subsidence of local engorgement.

The treatment of uncomplicated fracture limbs in general embrace but a few broad principles, which apply to all ages; they must, under certain conditions of age and environment be modified.

After all severe fractures the system sustains more or less shock. The body needs rest, no matter whether it be the upper or lower extremity which is involved. The patient should *first* be treated, then his injured limb. This should be comfortably adjusted, for if severe pain persist after the limb has been set, something is wrong.

On Splinting. As there is seldom much displacement, if any, in several varieties of fractures in children, we will do enough in many cases at the first visit, to simply place the limb at rest without any other investment than a bandage, until after the primary callus is formed, when a support is adjusted to obviate deflexion in the ossifying stage. Osseous apposition of the fragments with retention is desirable in those cases of fracture attended with much displacement.

In order to realize this end or to bring the divided ends of the bones into as convenient contact as possible and so retain them, we depend mainly on two or three things: the first, the most important and more valuable than all others combined, is *muscular relaxation*, or postural treatment. This permits unfettered liberty of the circulation, and the highest possible activity of the nutritive processes. In the lower extremity, for the leg, the foot may be used as a counter-extending force; in the thigh, both the leg and

foot. In the arm, the forearm is the counter-extending weight. With the child we have little to fear from bed-sores, and he bears enforced confinement with less impairment to health than many who after middle life accumulate additional flesh. Desault was the father of the method of fracture treatment now so generally adopted, in which the principles of muscular relaxation is so generally discarded. Long splints are applied and artificial extension is generally employed.

To enter into the comparative value of various methods would involve a large task, which can not be undertaken here, but, after fifteen years experience in a large traumatic surgical service in hospital and a fair share outside, I am convinced that mechanically splinting and confining *all* fractures is an error; that the results are not as satisfactory as they should be and that the time is not far distant when Pott's principles in fracture treatment will again reign supreme.

But even now, in fractures contiguous to or involving the articulations, our sole reliance is muscular relaxation and postural treatment.

Overlaying apparatus in joint fractures are little more than masks, which practically accomplish nothing. They, however, fulfill a psychical affect, something often highly necessary with the fault finding and supercilious.

Early passive motion, in my experience, is highly desirable in all fractures of children which involve the articulations. Not a few distinguished surgeons are opposed to it, in my judgment very much to the disadvantage of the injured.

Marked deflection of long shafts, after treatment is completed, very justly reflects discredit on the attending surgeon, when the child is constitutionally sound. It is most frequently seen in the female.

We may find that the patient has a lump of bone projecting outward where the shaft has the least muscular investment, the limb is very markedly shortened, and the patient walks with a limp. It is not my

intention to reflect on the surgeon for this blemish, for as a sequel of fracture treatment it may occur in the hands of anyone; only it should not be allowed to remain if of an aggravated type.

It is surprising how easily it is overcome if taken in hand early. The bone is then pliant and by the use of moderate force can be easily pressed into position, the bowing overcome and length restored. Some of these cases of deflexion are dependent on an organic defect in the osseous elements, a species of malnutrition not well understood; in all instances, however, it is well to favor consolidation of the fragments by close attention to the hygienic surroundings, proper nourishment, tonic and reconstructive medicines.

Massage, bathing, kneading the muscles and frequent changing the position of the patient are helpful aids; and as Championiere has lately demonstrated, entirely innocuous as disturbing agents of the approximate fragments.

On the Treatment of Complicated Fractures or Open Compound Fractures.—Although every fracture not attended with an open wound is designated "simple," under very many circumstances it leads to a wrong inference; hence it would seem both desirable and necessary that in every instance when the arthritic, neural or vascular structure, to a considerable degree, share in the traumatic disorganization of bone, the word *complicated* should be substituted for "simple" and the word *open* for "compound."

To the inexperienced the word "compound fracture" has a most serious significance, while as a matter of fact not a few of the cases embraced under this class recover with better limbs than the "simple." And, of the latter, occasional instances occur, when the damage to the fractured limb is so great, as to, later, demand amputation or lead to a wasting or ankylosis of the limb.

Modern measures, inhibiting germ infection, great advances in osteoplastic science, combined with per-

fect mechanical adjustment and prosthetic devices, under no circumstances justify the sacrifice of a limb or a part of a limb after an injury in a child, unless the parts have suffered *total* death by violence.

In open, compound fractures of the limbs our first concern must be to arrest hemorrhage. This should be done as far as possible by exposure, ligation, torsion or immediate compression of the spouting arteries. When bleeding is venous or parenchymatous, moderate tamponage and bandage pressure will answer for its suppression; but under all circumstances very hot water as a styptic or protracted elastic compression, with Esmarch's bandage, as a hemostatic agent must be condemned; the former for its destructive action on the vital structures and the protoplasm, and the latter, from the danger of gangrene following.

Our next step is cleanliness and all that it implies in a strict surgical sense. Now, we will endeavor to comfortably adjust the fragments and provide them necessary support, under appropriate dressings until general and local reaction is established. In the average case of severe open shattering of bone, with more or less displacement and extensive mangling of the tissues, the safest course of practice to pursue is not to undertake too much at the primary dressing.

From a theoretic standpoint this advice may seem untenable and injudicious.

The parts, it is true, are now more or less benumbed, and may be handled with less pain; yet in all cases in which any tedious manipulation is necessary an anesthetic must be employed. But in all these cases severe constitutional shock is present, muscular spasm drags on the fragments and infection is so constant that primary union seldom follows without suppuration and limited gangrene of the damaged parts.

Better by far, in all very serious cases of this class to be contented with temporary adjustment of the mangled limb, secure against fresh infection and hemorrhage for at least twenty-four or forty-eight

hours or longer, unless special indication call for a change.

The question as to what we shall do with the displaced fragments to secure their surfaces in permanent contact, by wiring, pegging or riveting; what fragments we shall return and what detach, how we shall place the osseous structures in position most favorable to regeneration, when there has been much loss of bone substance, belongs to the subject of osteoplasty, a branch of the healing art which every surgeon must familiarize himself with and master who would perform his whole duty to his patient. As this subject is too large to be considered in this brochure, it is enough to say what my own experience long ago convinced me of, viz., that under no circumstances should any fragments of bone be removed that preserve an intimate attachment with the soft parts. In the upper extremity our every effort should be strained to preserve every possible particle of bone tissue that possesses a cutaneous investment, and no excision or division should be done through any other than parts hopelessly devitalized.

Modern prothetic appliances have done much to substitute a sacrificed limb, at least for appearance, though as an appendage for the lower extremity they sometimes support the body and carry it; nevertheless, let no one deceive himself into supposing that any artificial support can ever fulfill the purposes of a natural one, and needlessly sacrifice any part of the lower extremity.

There are several reasons why a severe fracture through any part of the lower extremity is more difficult to treat than in the upper. It is here where fracture is very common, and in railway or other serious accidents the greatest extent of mutilation is inflicted. Yet, when we can provide proper attention to a case it is surprising what results we may realize in many of the frightful cases of bone disorganization.

As an example, I might mention one case of open

fracture in a child of 6 years, run over by a street car, in whom the entire tibial shaft was so shattered that it was entirely shelled out through the long breach in the tissues. Only the epiphyseal ends and periosteum remained. In one year this entire shaft was regenerated; there was no shortening and no limping. In another, a young adult, the bones were so smashed that a little more than four inches of the shafts of the tibia and fibula on damaged side had to be removed, and the widely separated ends pressed together. In six months union was complete. By a rise on sole of shoe shortening is compensated for, no crutch or walkingcane is used, and last autumn he won a wager, walking from One Hundred and Twenty-fifth Street, in Harlem, to Coney Island, a distance of about twenty-one miles, leaving Harlem at 6 in the morning and returning before 6 in the evening. This he accomplished with ease.

We can secure surprising results in most any description of fracture in the leg of a child, below the knee, provided the circulation be intact; but when the fleshy parts are torn open in femoral fracture, we have good grounds for the most serious apprehension.

The extent of shock is always very great, in compound, femoral fracture, and in most cases there is considerable loss of blood before efficient surgical care can be rendered. In spite of anything that we can do to prevent it infection will set in and spread, always endangering life through infiltration, resorption and pyemia.

There are several varieties of fracture of common occurrence in the adult, rarely or never seen in the child. In them I have never seen a fractured patella or a Pott's fracture. One instance of intracapsular fracture at the hip has come under my care, in a youth of sixteen years. Subsequent to the injury necroses of the surface of the distal fragment developed and provoked suppuration. On incision, through the anterior plane of muscles, the capsule was opened and the neck was cleared away and the head

left. The operation was performed four years ago. The patient is now a full-grown man with a very useful limb, except for about three inches shortening.

I never yet met with a case of Colles' fracture in a child, although some authors speak of it occurring during the stages of growth. I doubt their accuracy of diagnosis. Colles' fracture almost invariably leaves deformity through rupture of the internal lateral ligament and displacement outward of the head of the ulna, impaction and diastasis of the radial head.

Deformities, therefore, should be rarer after juvenile fracture, functional restoration better and restoration of strength greater after treatment than with those approaching or after the meridian of life.

In conclusion, as far as treatment is concerned, it may be said that as applied to so-called "simple" fractures, or the complicated, involving the joints, in the child there has been no special progress made in late years, the mechanical problem is not settled and our best authorities are not in accord on the question of attitude or position of the limb, on immobilization, extension and counter extension. The fact is, that mechanical aids in fracture have but a limited application, as we are dealing with a living machine not subservient to any physical laws in its vital processes.

Enduring progress only has been made with the complicated and open fractures, in which, by adoption of antiseptic methods and osteoplasty, safe conservatism is possible, and now we are enabled to preserve limbs formerly condemned to amputation or a crippled condition, which rendered them little more than useless.



